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(54) **Communicating code branch allocation for CDMA system**

(57) There is disclosed a method of communicating a selected channelisation code for a downlink to a user, comprising: transmitting a set of nodes of a code tree comprising a defined path of the tree for the user; and transmitting an identifier identifying one of the set of nodes to be used.

FIG. 7

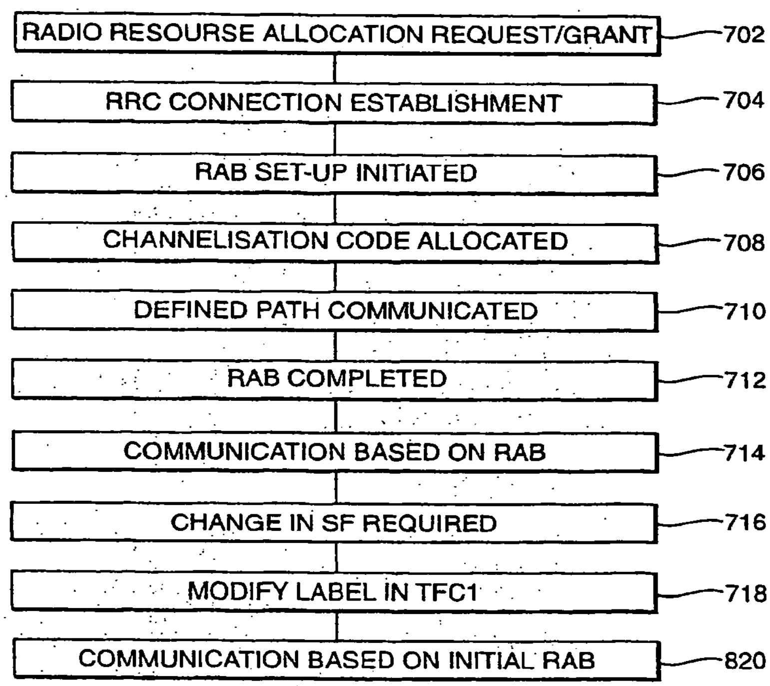

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Figure 6 illustrates the general steps in communicating a channelisation code for the downlink according to a known technique; and

Figure 7 illustrates the general steps in communicating a channelisation code for the downlink according to a new technique.

Description of Preferred Embodiment

[0012] The new technique for allocating channelisation codes described herein applies equally to channelisation code allocation in the uplink and the downlink. In the following description a general introduction to the concept of channelisation codes is given, followed by an overview of one current technique for allocating channelisation codes. Thereafter, the new technique of allocation of channelisation codes is described.

[0013] The channelisation codes for UMTS for the uplink as well as for the downlink are orthogonal variable spreading factor (OVSF) codes which maintain orthogonality between the different physical channels of one base station (downlink) or one mobile station (uplink), respectively. The OVSF codes can be described using the code tree of Figure 1.

[0014] The OVSF sequences are denoted by $C_{x,y}$ ($y=1,\ldots,x$; $x=2^{k-1}$, $k=1,\ldots,9$). Each level in the code tree defines channelisation codes corresponding to a spreading factor of SF=x. The code with $C_{2x,2y-1}$ of the upper branch will be constructed by concatenation of two codes $C_{x,y}$ from the previous node. Thus for example, node $C_{4x,4y-3}$ is the concatenation of the node $C_{2x,2y-1}$ twice, which is in turn the concatenation of the node $C_{x,y}$ twice. $C_{2x,2y}$ from the lower branch is determined by the concatenation of one code $C_{x,y}$ and its negative $-C_{x,y}$. Thus, for example, the node $C_{4x,4y}$ is the concatenation of $C_{2x,2y}$ with its negative, which in turn is the concatenation of the node $C_{x,y}$ with its negative. The concatenation of nodes is illustrated in Figure 1.

[0015] All codes within the code tree, as discussed hereinbelow, cannot be used simultaneously. In a known code allocation scheme (discussed in further detail hereinbelow), a code can be used for a physical channel if and only if no other code on the path from the specific code to the root of the tree or in the sub-tree below the specific code is used by another physical channel.

[0016] This concept is described in further detail hereinbelow, with reference to a specific example.

[0017] The general steps to be taken in a known scheme for allocating channelisation codes in a downlink are described below. It will be appreciated by one skilled in the art how this technique may be utilised in the uplink.

[0018] In the down link the code tree is shared by all users, and a branch of the code tree is allocated for each user, each user having a unique channelisation code. This allocation effectively comprises two steps which are discussed in further detail hereinafter: defining an origin node on the tree; and defining a path from the origin node on the tree.

[0019] A channelisation code is typically allocated for a number of expected symbol rates, the symbol rate in turn determining the spreading factor. That is, the down link channelisation code allocated to a particular user is based on the fact that it is known the user will require a symbol rate within a particular range. Thus channelisation codes within this range must be allocated. For allocation and de-allocation of radio resources, the highest symbol rate, i.e. the lowest spreading factor, first needs to be determined. This then gives the channelisation code for the lowest spreading factor, and defines the origin node, or initial node, in the code tree.

[0020] In this known technique, a node (and its subtree) can be assigned to one physical channel if and only if no other node on the path from the specific node to the root of the tree or in the sub-tree below the specific node is used by another physical channel from the same base station (downlink). Thus the code tree must be looked into in both directions from the initial node.

[0021] From observation of the code tree of Figure 1, this requirement can be defined by two rules as follows:

[0022] 1. If the origin node with code $C_{x,y}$ ($x=2^{k-1}$; $y<x$) is used, all subsequent nodes (in the downward direction) with code $C_{v.x,v(y-1)+\mu}$ ($v=2^n$; $n\geq 0$ and $\mu=1,\ldots,v$) are reserved or occupied and cannot be used by another physical channel.

[0023] 2. From $C_{x,y}$ ($x=2^{k-1}$, $y<x$), in the upward direction, all codes with $C_{v.x,[v.y]}$, ($v=2^n$, $n\leq 0$) are reserved or occupied and cannot be used by another physical channel. The term [v.y] denotes the next highest integer number of (v.y).

[0024] Rule 1 must be considered for allocation of sequences with a spreading factor of interest of SF≥x; Rule 2 is for allocation of sequences with a spreading factor of interest of SF≤x.

[0025] The allocation of channelisation codes in the downlink according to a known technique will now be described with reference the flow chart of Figure 2 and the specific example as illustrated by Figure 3

[0026] In this example, it is assumed that there are three users. A first user requires a channelisation code with a spreading factor in the range of 4 to 8, a second user requires a channelisation code with a spreading factor in the range 4 to 8, and a third user requires a channelisation code with a spreading factor in the range 2 to 8.

[0027] In a first step 202, a code tree is allocated for the downlink, being the code tree generally shown in Figure 3. In a second step 204, the number of users is determined, and a parameter M set to be equal to the number of users. In the present example M is set equal to 3. At this stage a further parameter N is set to a value 1.

[0028] In a step 206, an origin node for the user N, i.e. the first user, is determined. The origin node for each user is determined based on the lowest required spread-

based upon the required spreading factor given the amount of data to be transmitted in the downlink associated with each user. For the purposes of the present example it is assumed that the first user has a required spreading factor of 8, the second user has a required spreading factor of 16, and the third user has a required spreading factor of 8.

[0043] In a step 226 communication then proceeds in the normal way.

[0044] The new code allocation technique improves on the above-described technique, by enabling channelisation codes to be re-used. Again, a specific example is given herein with reference to the downlink, but it will be readily understood how the technique extends to the uplink. Figure 4 is a flow diagram illustrating the general principles of the new technique, and Figure 5 represents a specific example to illustrate the new technique.

[0045] In the new technique a code tree for use in the down link is allocated, as before, in a step 402. The allocated code tree is shown in Figures 5(a) and 5(b) and corresponds to the code tree of Figure 3.

[0046] For the purposes of the present example according to the invention it is again considered that there are the same three users. In a step 404, corresponding to step 204, the parameter M is set to the number of users (3), and the parameter N is set to 1.

[0047] In a step 406 origin nodes are allocated for each of the users. The origin nodes may be allocated to each user irrespective of the origin nodes allocated to other users. In the present example, as illustrated by Figure 5(a), node C4,1 is allocated as the origin node for both the first and second users, and node C2,2 is allocated as the origin node for the third user.

[0048] It will be appreciated, however, that the technique for allocating the origin node may vary and will be implementation dependent. It will be understood that if there were three users each with a minimum spreading factor of 2, then one of the nodes C2,1 and C2,2 would be allocated twice. In the prior technique described hereinabove, if there were three users each with a minimum spreading factor of 2 then there would not be sufficient codes to allocate. Obviously, this concept extends to more realistic examples. If there were seventeen users each with a minimum spreading factor of 16, then in the prior technique there would not be sufficient channelisation codes to allocate. In the present invention, one of the nodes C16,1 ... C16,16 would be allocated twice.

[0049] A method must generally be provided to arrange the origin nodes associated with different channelisation codes within the code tree, rather than the origin nodes being arbitrarily allocated. It is assumed that the RRA (radio resource allocation) algorithm has successfully checked the requested resources against the code space (i.e. the RRA algorithm has checked that there is sufficient code space to allocate resources to the users). Several methods for the arrangement of origin nodes are possible. Two particularly advantageous practical solutions are described below.

[0050] In a first solution, at every run of the RRA algorithm, all physical channels are sorted according to the necessary spreading factor. The sequences will be allocated in order of their spreading factor: e. g. at first the channels with highest spreading factor will be allocated to codes $C_{x,y}$ with smallest x and y, then channels with next lower SF will be allocated to nodes $C_{x,y}$ with higher x and y etc. This procedure must be done iteratively, because after every allocation of a node to a channel an indication that subsequent and previous nodes are not available must be done according to Rules 1 and 2. This method of allocation / de-allocation of nodes is simple, because all connections are handled equally as new connections. At every change of at least one channelisation code a complete reshuffling of the code tree is done.

[0051] In a second solution, the channelisation codes are allocated according to the time of arrival of the RRC (radio resource control) connection requests. The allocation may be as follows. The first available code $C_{x,y}$ with minimum x and y is given to the first incoming request, the next available code to the next request etc. Thus, code shuffling due to changes of a channelisation code is only done in the case that code branches starting with nodes of a higher spreading factor on different paths can be combined to avoid waste of code space (similar to de-fragmentation). Allocation and de-allocation of the nodes must be done in consecutive steps, because the connections are now of three types: released, changed and new ones.

[0052] In addition to the two above alternative methods for allocating origin nodes, nodes with a bad interference situation can be considered as not preferred. If there is enough code space available, then the code sequence of such nodes should not be used.

[0053] Once the origin nodes are allocated, then the paths for each user are defined in a step 408. In the illustrated example of Figure 5(a), for the first user a path from the origin node U10 extends through nodes C8,1 and node C16,1, designated by numerals U1. For the second user a path extends from the origin node U20 to node C8,2 designated by U2. For the third user a path extends from the origin node U30, through nodes C4,3 and C8, 5 designated by U3.

[0054] Based on the amount of data to be transmitted in a particular communication, the spreading factor for the first user (user N) is then determined in a step 410. For the first user a required spreading factor of 8 is determined (as before) and node C 8,2 therefore selected for use in the downlink of the first user. In accordance with the new technique, in a step 412 the Rules 1 and 2 are then applied in dependence on the selected node for the first user. Referring to Figure 5(b), the selected node for the first user is designated by SU1, and the nodes in the upward and downward direction therefrom reserved, as designated by RU1.

cussed further hereinbelow, operates.

[0072] In a step 608 the code for the user to use is determined, in accordance with the techniques of either Figure 2 or 4, and then in a step 610 the selected node only of the code path allocated to the user is communicated to the user. Thus at this stage, the required spreading factor for the communication session is determined such that only the one of the nodes of the defined branch which is required for the current communication session is selected and communicated to the user.

[0073] In a step 612 the RAB procedure is completed, and then in a step 614 the downlink communication between the user and the mobile station proceeds based on the established RAB.

[0074] In a step 616, a change in the spreading factor for the particular user is required due, for example, to a change in the volume of data to be transmitted. In a step 618 a RAB request is initiated, and then in step 620 a RAB is performed, and a new selected node of the branch communicated to the user. In a step 622 the RAB is completed, and then in a step 624 communication continues based on the newly established RAB.

[0075] Thus once communication is established, every time there is a change required in the spreading factor of the channelisation code, due for example to a change in the bandwidth, then a new RAB establishment must take place.

[0076] The new advantageous technique for establishing the downlink is now described with reference to Figure 7. As before, if the downlink communication is initiated by a user, then in a step 702 a radio resource allocation establishment takes place. This consists of a user sending a radio resource allocation request to the base station, and the base station sending a radio resource allocation grant signal back to the user. In a step 704 a radio resource control (RRC) establishment takes place. In a step 706 a radio access bearer (RAB) set-up procedure is initiated to establish the physical channel.

[0077] In a step 708 a channelisation code is allocated to the user, preferably in accordance with the technique of Figure 4.

[0078] In a step 710, the branch defined for the particular user is communicated to the user. That is, all possible nodes of the defined path are communicated to the user.

[0079] The allocated code path, i.e. the defined path, is communicated to the user during RAB establishment when the Transport Format (TF) and the Transport Format Combination Set (TFCS) is transmitted to the user via the RRC connection. The transport format consists of a dynamic part and a semi-static parts. The dynamic part is modified to include downlink channelisation code labels (x_d, y_d such that $C_{xd,yd}$).

[0080] Thus, referring to the example of Figures 5(a) and 5(b) hereinabove, for user 1 the downlink channelisation code labels [4,1; 8,2] would be sent, defining the path shown by U10 through U1 in Figure 5(a). For user 2 the downlink channelisation code labels [4,1; 8,1; 16,1] would be sent, defining the path shown by U20 through U2 in Figure 5(a). For user 3 the downlink channelisation code labels [2,2; 4,3; 8,5] would be sent, defining the path shown by U30 through U3 in Figure 5(a).

[0081] The semi-static part remains as before. The purpose of adding the labels of the downlink channelisation codes is to accommodate fast changing of the spreading factor and its corresponding channelisation code.

[0082] Then in a step 712 the RAB establishment is complete.

[0083] In a step 714, a communication based on the established RAB takes place. The data packets sent during the communication each include a transport format communication indicator (TFCI), and according to the new technique the TFCI is modified to include an identifier identifying the one of the set of nodes sent to the user in the TFS during RAB establishment to be selected for use in the downlink. Thus, again referring back to the example of

[0084] Figures 5(a) and 5(b), for user 1 the TFCI will identify the second of the channelisation code labels sent during the RAB establishment.

[0085] In a step 716, a change in the spreading factor is required. In a step 718 the label in the TFCI of the data packets is therefore modified with the node of the branch for the new spreading factor, then in a step 720 the communication continues based on the originally established RAB.

[0086] Thus it can be seen that by communicating all possible nodes of the defined path for a user to the user during the RAB establishment, there is no requirement for the RAB establishment to be repeated each time there is a need to change the spreading factor, as is the case in the prior art.

Claims

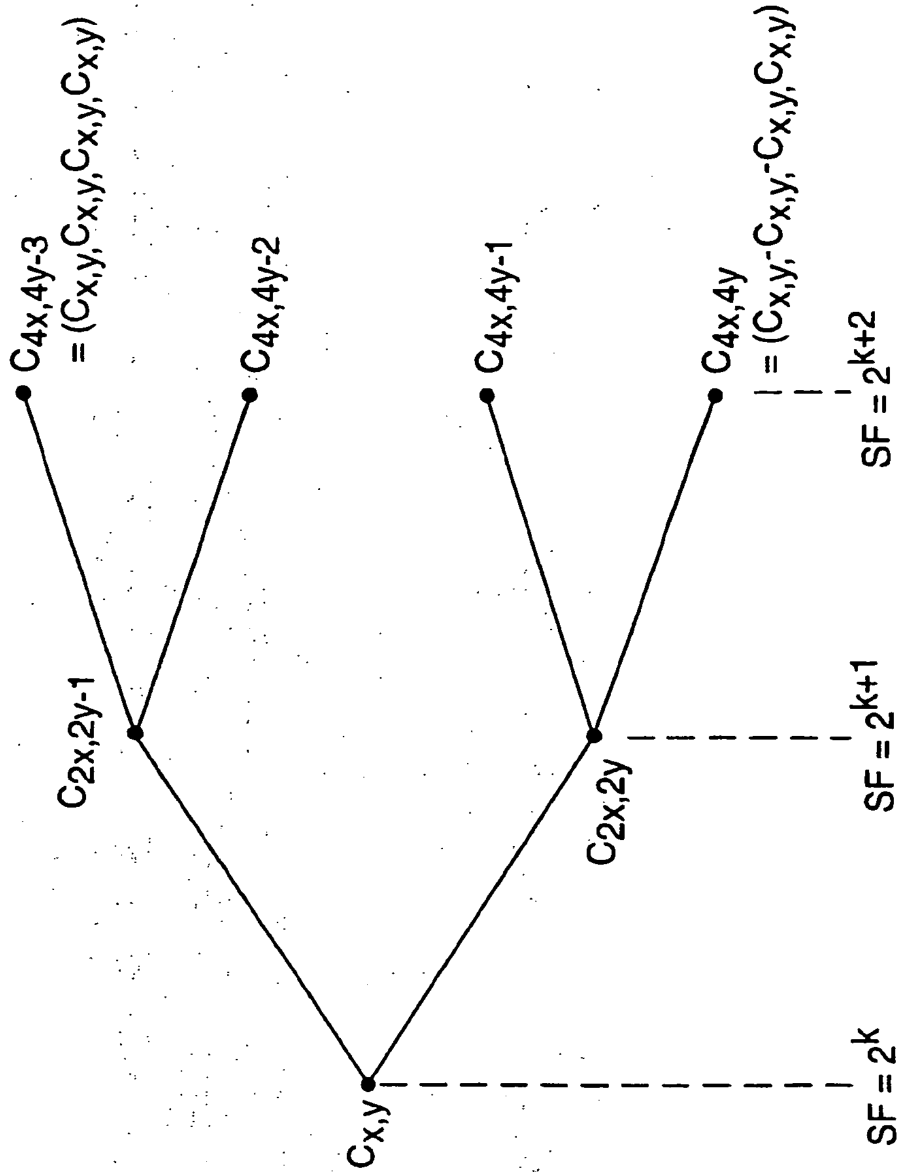
1. A method of communicating a selected channelisation code for a downlink to a user, comprising: transmitting a set of nodes of a code tree comprising a defined path of the tree for the user; and transmitting an identifier identifying one of the set of nodes to be used.

2. The method of claim 1 wherein the set of nodes are transmitted to the user during the radio access bearer establishment session between the user and a base station.

3. The method of claim 2 wherein the set of nodes are included in the transport format set.

4. The method of claim 1 or claim 2 wherein the identifier is transmitted in a data packet.

FIG.1


$C_{4x,4y-3}$
$= (C_{x,y}, C_{x,y}, C_{x,y}, C_{x,y})$
$C_{4x,4y-2}$
$C_{4x,4y-1}$
$C_{4x,4y}$
$= (C_{x,y}, -C_{x,y}, -C_{x,y}, C_{x,y})$
$C_{2x,2y-1}$
$C_{2x,2y}$
$C_{x,y}$
$SF = 2^{k+2}$
$SF = 2^{k+1}$
$SF = 2^{k}$

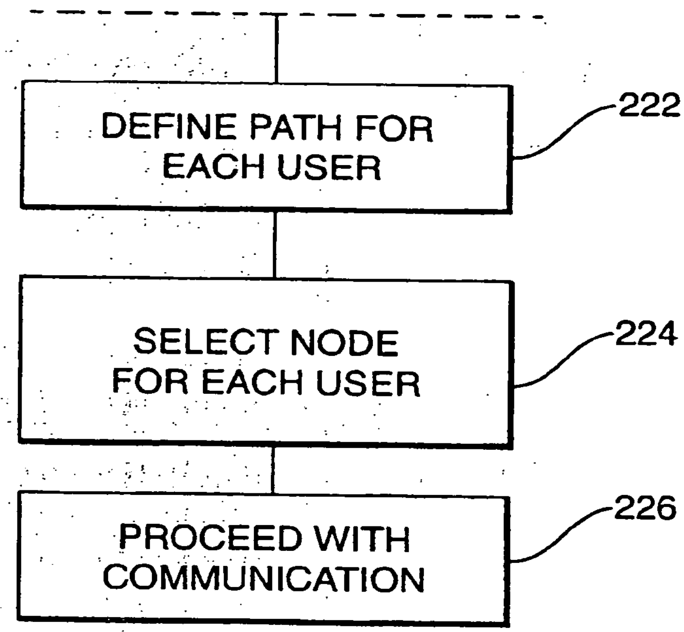

DEFINE PATH FOR EACH USER
222
SELECT NODE FOR EACH USER
224
PROCEED WITH COMMUNICATION
226

FIG. 2 (contd.)

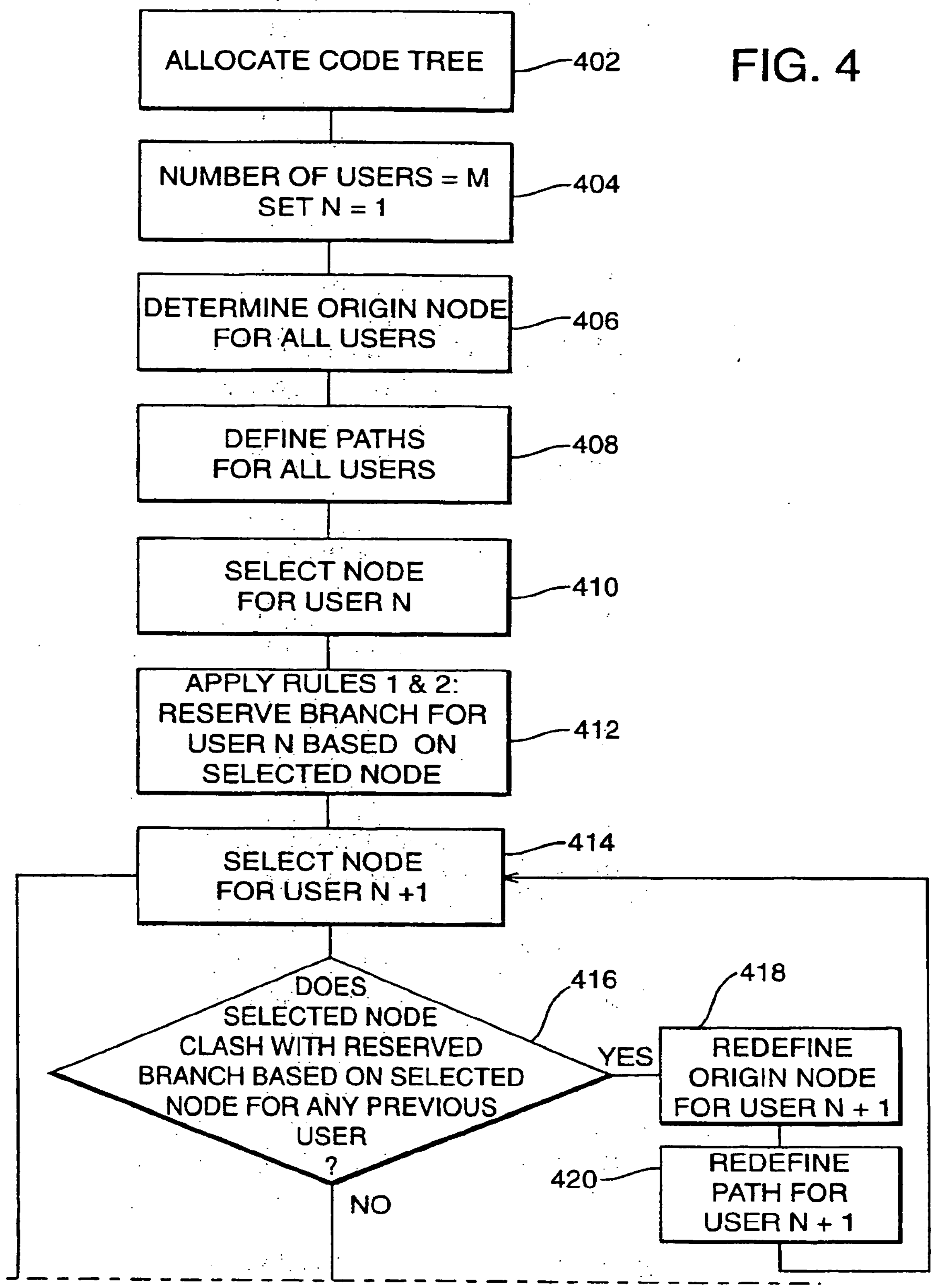

ALLOCATE CODE TREE
402
NUMBER OF USERS = M
SET N = 1
404
DETERMINE ORIGIN NODE
FOR ALL USERS
406
DEFINE PATHS
FOR ALL USERS
408
SELECT NODE
FOR USER N
410
APPLY RULES 1 & 2:
RESERVE BRANCH FOR
USER N BASED ON
SELECTED NODE
412
SELECT NODE
FOR USER N +1
414
DOES
SELECTED NODE
CLASH WITH RESERVED
BRANCH BASED ON SELECTED
NODE FOR ANY PREVIOUS
USER
?
416
YES
NO
REDEFINE
ORIGIN NODE
FOR USER N + 1
418
REDEFINE
PATH FOR
USER N + 1
420

FIG. 4

FIG. 5(a)

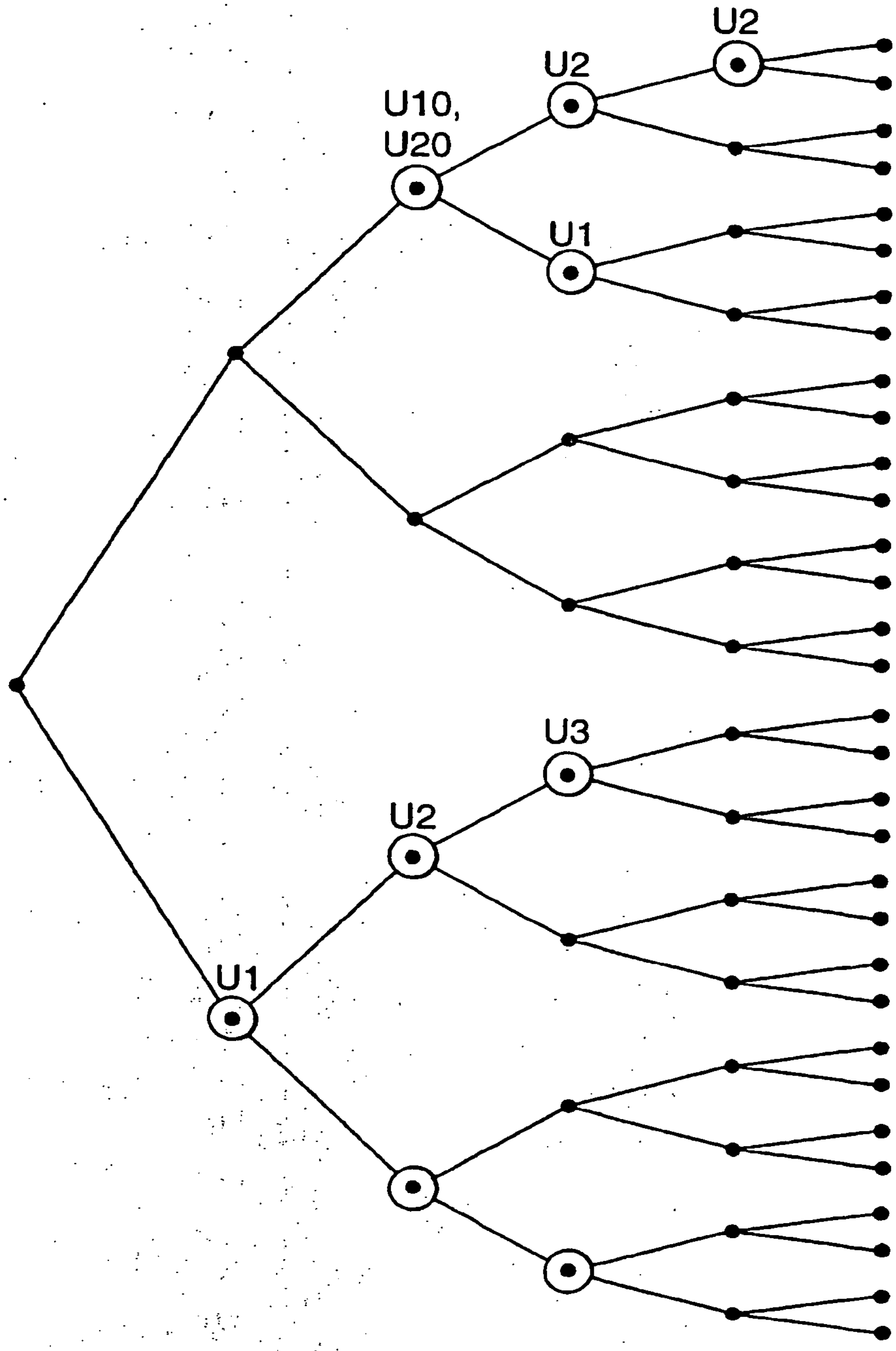
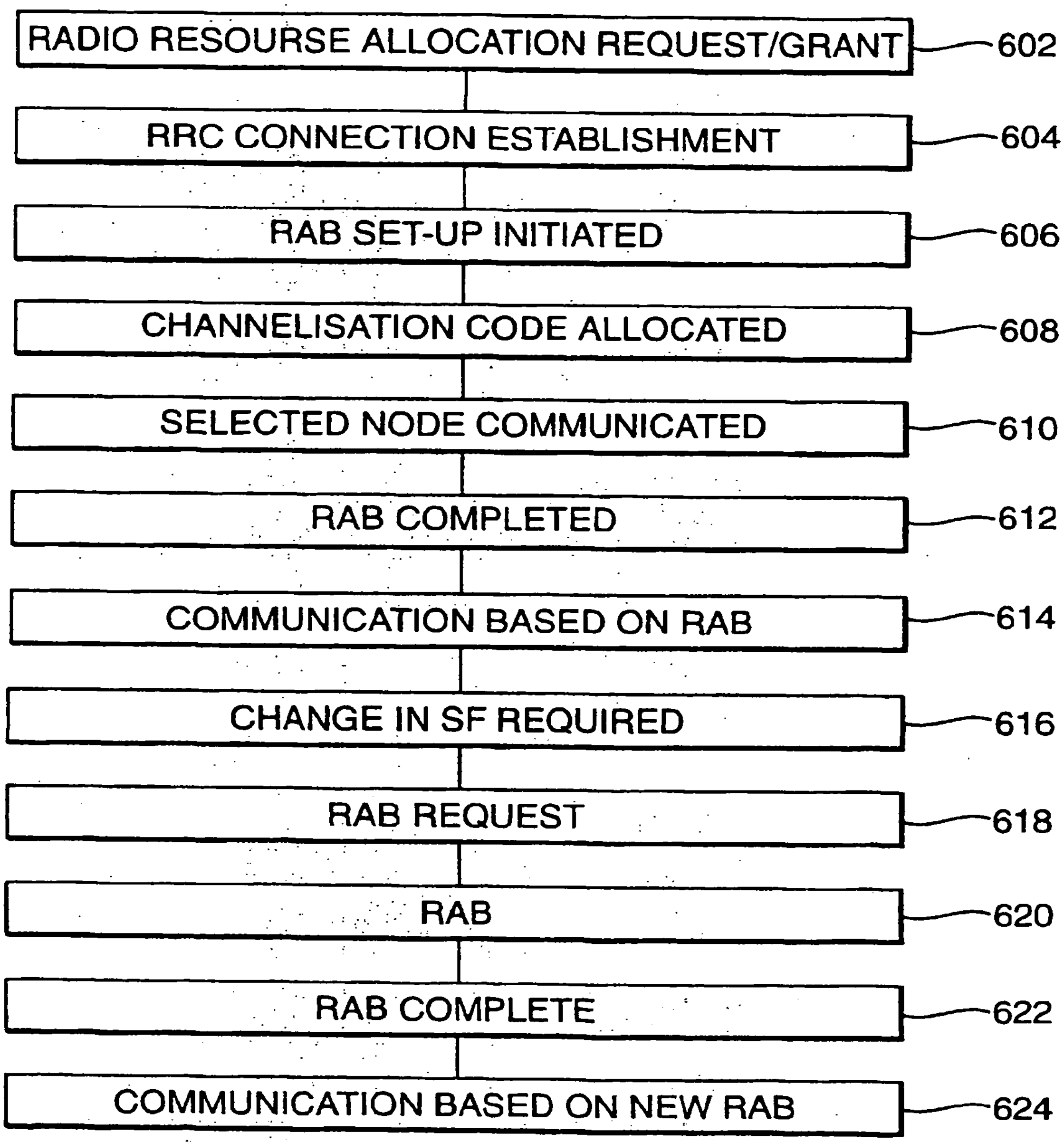


FIG. 6


RADIO RESOURSE ALLOCATION REQUEST/GRANT
602
RRC CONNECTION ESTABLISHMENT
604
RAB SET-UP INITIATED
606
CHANNELISATION CODE ALLOCATED
608
SELECTED NODE COMMUNICATED
610
RAB COMPLETED
612
COMMUNICATION BASED ON RAB
614
CHANGE IN SF REQUIRED
616
RAB REQUEST
618
RAB
620
RAB COMPLETE
622
COMMUNICATION BASED ON NEW RAB
624

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 1809

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	WO 95 03652 A (QUALCOMM INC) 2 February 1995 (1995-02-02) * page 4, line 1 - line 18 * * page 13, line 30 - page 17, line 17 * * page 26, line 25 - line 2 * * abstract; claims 1-19; figure 2 *	1,2	H04J11/00 H04Q7/38
X	I C -L ET AL: "MULTI-CODE CDMA WIRELESS PERSONAL COMMUNICATIONS NETWORKS" COMMUNICATIONS - GATEWAY TO GLOBALIZATION. PROCEEDINGS OF THE CONFERENCE ON COMMUNICATIONS, SEATTLE, JUNE 18 - 22, 1995, vol. 2, 18 June 1995 (1995-06-18), pages 1060-1064, XP000533158 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERSISBN: 0-7803-2487-0 * page 1060, paragraph 4 * * page 1062, right-hand column, line 11 - page 1063, left-hand column, line 30 *	1,2	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			H04Q H04B H04J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 August 1999	Coppieters, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document